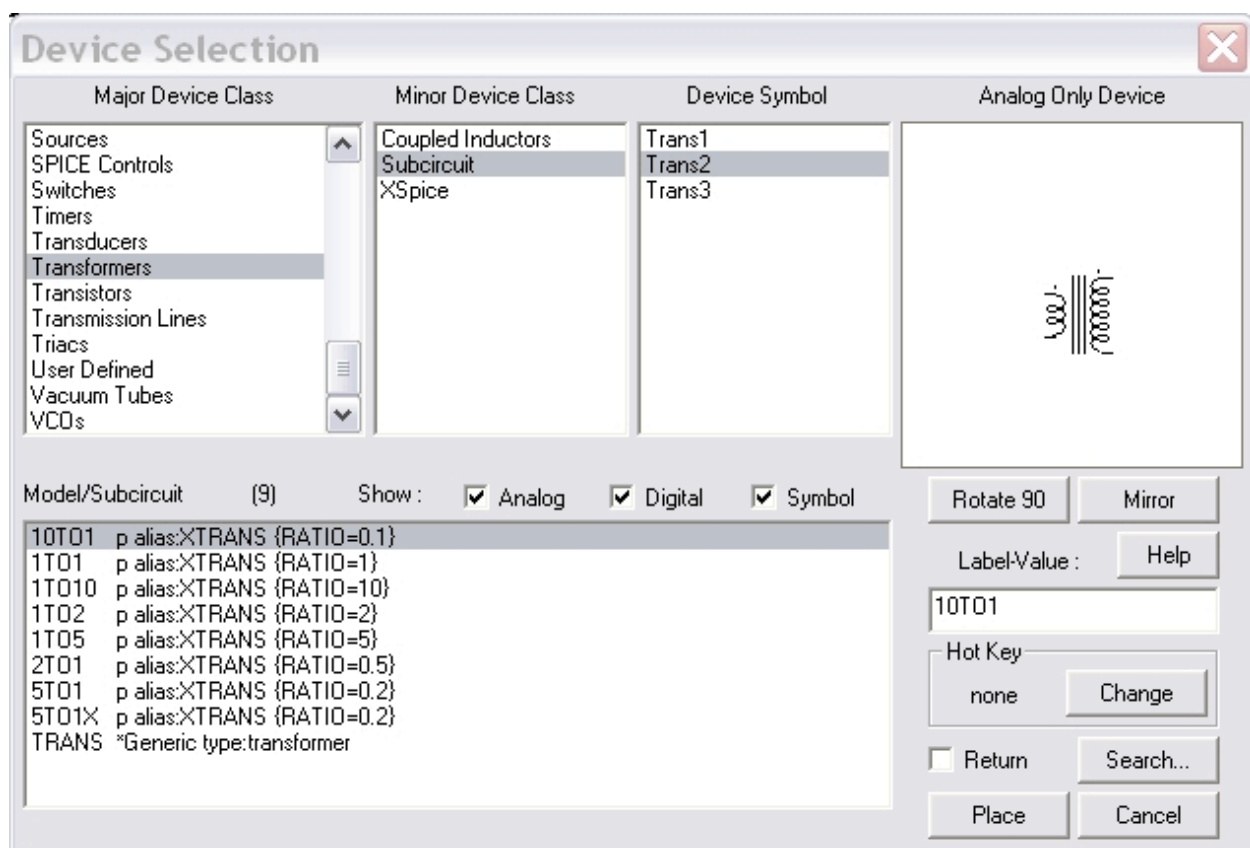


## MMI401 Lab 4

### Transformers

In this lab you are going to simulate the most common uses of transformers. Circuit Maker is OK at some things like voltage, current and power calculations, but it does not simulate the impedance matching characteristics or the inductance, parasitic capacitances, or proper frequency responses. It's still useful and nearly impossible to design a tube power amp without. These will be easy circuits to simulate and report on.

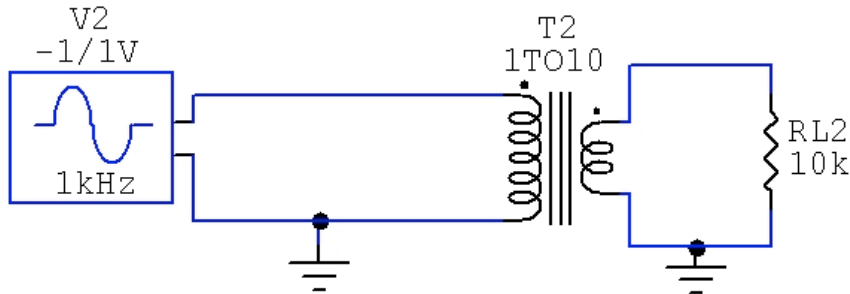
When you choose transformers, use the Trans2 and Trans3 subgroups:



Trans3 gives you the center tapped variations. Trans2 is the same as Trans1 except for the way the transformer is drawn; Trans2 depicts the difference in coil turns graphically.

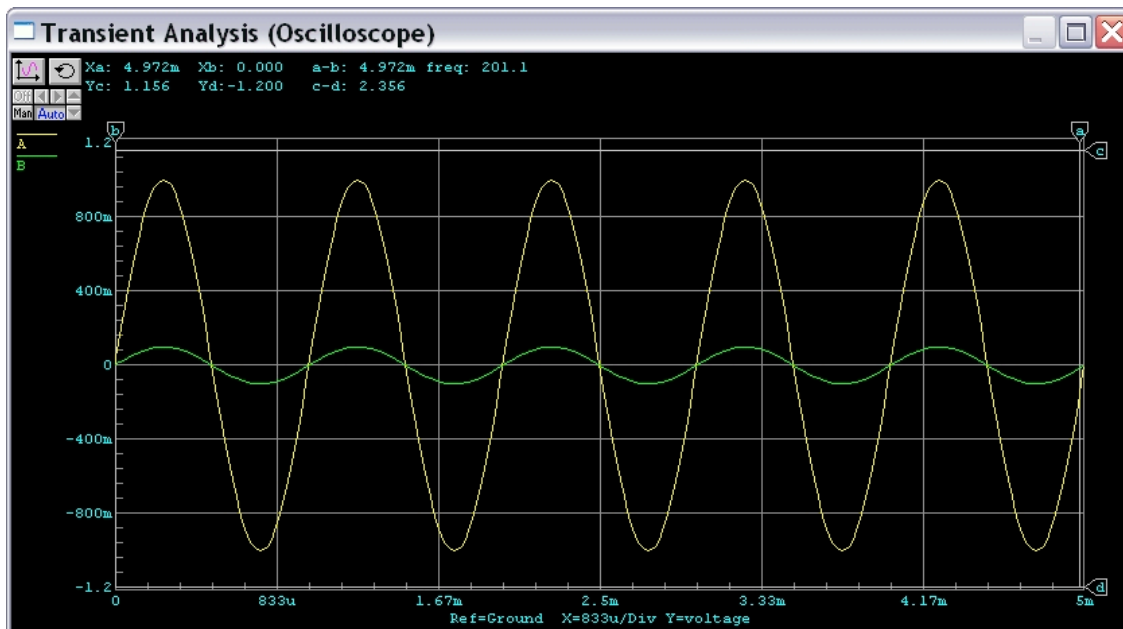
## Circuit 1: 1:10 Step Down Transformer

Create a circuit with an AC source connected to a 1:10 transformer (non center tapped) which is connected to a 10k load resistor like this:



The turns ratio is 1:10 or  $n_p:n_s$  so the voltage gain/attenuation is  $V_p/V_s$ .

- Verify mathematically that this will create a step-down transformer that attenuates the signal by -20dB
- Probe the load resistor to verify this; hold the shift key down and plot the input and output Transient Response relationship. The Frequency Response is flat; in Auto mode it zooms to show a rolloff but on the left you will see every gridline says -20 -- this is a flat response (hit the Man button to see)
- Your transient analysis should look like the one below
- Use Circuit Maker to verify the voltage transfer through the transformer.



**Submit** your design equations and Schematic and Frequency Response plots for your Lab Report. Make sure you describe and label your figures so the TA gives you full credit.

### **Circuit 2: 10:1 Step Up Transformer**

Cut the transformer out of the circuit with <Ctrl> X, then paste it back again with <Ctrl>V and right click to choose Mirror so we can turn it around into a 10:1 transformer (even though CM will still label it as 1:10).

- Verify mathematically that this will create a step-down transformer that amplifies the signal by +20dB
- Probe the load resistor to verify this; hold the shift key down and plot the input and output Transient Response relationship.
- Use Circuit Maker to verify the voltage transfer through the transformer (+20dB)

**Submit** your design equations and Schematic and Transient Response and Frequency Response plots for your Lab Report. Make sure you describe and label your figures so the TA gives you full credit.

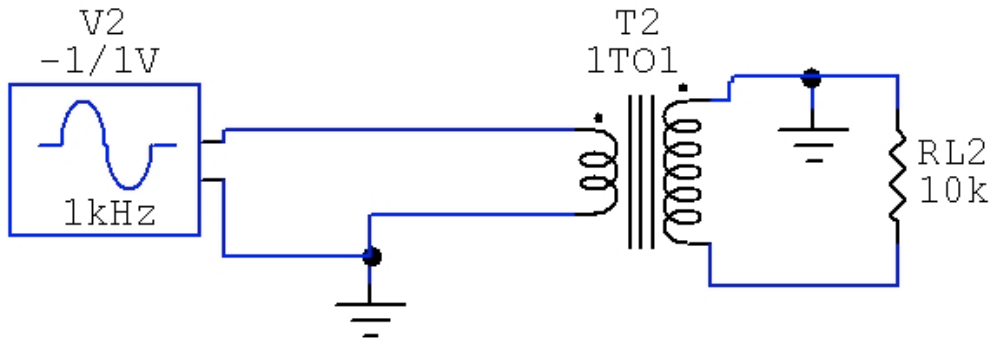
### **Circuit 3: The 1:1 isolation Transformer**

You might think a 1:1 Transformer is useless, but you find them all the time in pro audio applications. Even though the voltage transfer is unity gain, the transformer blocks DC voltages from the input or output side. Because Ground is a DC voltage of 0.0V, this means the transformer can also isolate the grounds of two systems. Ground loops cause AC hum in audio equipment when their grounds run off of different circuits in your studio. Adding the 1:1 isolation transformer fixes that noise problem.

**Circuit Maker can't give you multiple grounds to isolate. And unfortunately its software engineers forgot to simulate the ability to remove DC offsets :** (

But you can also use a 1:1 Isolation Transformer as a Phase Inverter by connecting the phase-dots correctly on the circuit.

Change the transformer in your circuit to a 1:1 type and connect the output for phase inversion:

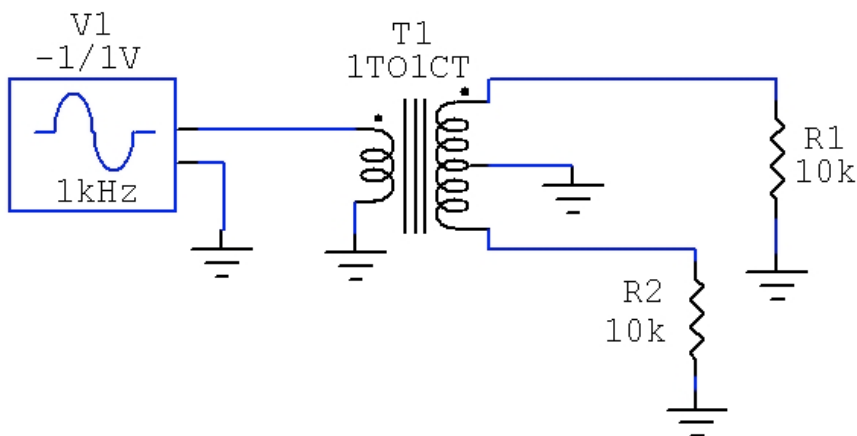


- Probe the load resistor to verify that the output (bottom of RL2) and the input are 180 degrees out of phase with each other.
- Use Circuit Maker to verify the voltage transfer through the transformer (unity gain)

**Submit** your Schematic and Transient Response and Frequency Response plots for your Lab Report. Make sure you describe and label your figures so the TA gives you full credit.

#### Circuit 4: Unbalanced to Balanced Conversion

Center tapped transformers can be used to convert unbalanced to balanced (and vice versa). Use a 1:1 Center Tapped (CT) Transformer and connect the center tap to ground. Simulate a load resistance of 10k on each of the balanced outputs.

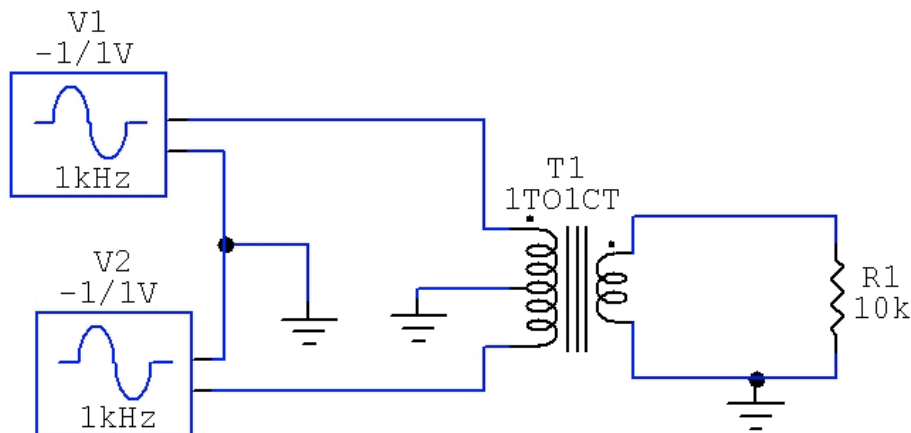


- Probe the 2 load resistors and input all at the same time (hold down the shift key) and you will get a plot that shows the AC voltage at each load is 1/2 of the input.
- Describe why the AC voltage at each load is 1/2 of the input.

**Submit** your Schematic and Transient Response plots for your Lab Report. Make sure you describe and label your figures so the TA gives you full credit. Answer the question about the AC output signals.

### Circuit 5: Balanced to Unbalanced Conversion

Create a new circuit with a balanced source using two signal generators. Mirror the 1:1 CT Transformer so the CT is swapped and connect to unbalance the signal.



- Probe the load resistor and inputs all at the same time (hold down the shift key) and verify that the new signal is an unbalanced version.
- Describe why the AC voltage at each load is 2x that of the input.

**Submit** your Schematic and Transient Response plots for your Lab Report. Make sure you describe and label your figures so the TA gives you full credit. Answer the question about the AC output signal.

## Circuit 1

$$\frac{n_p}{n_s} = \frac{V_p}{V_s}$$

$$\frac{1}{10} = \frac{V_p}{V_s}$$

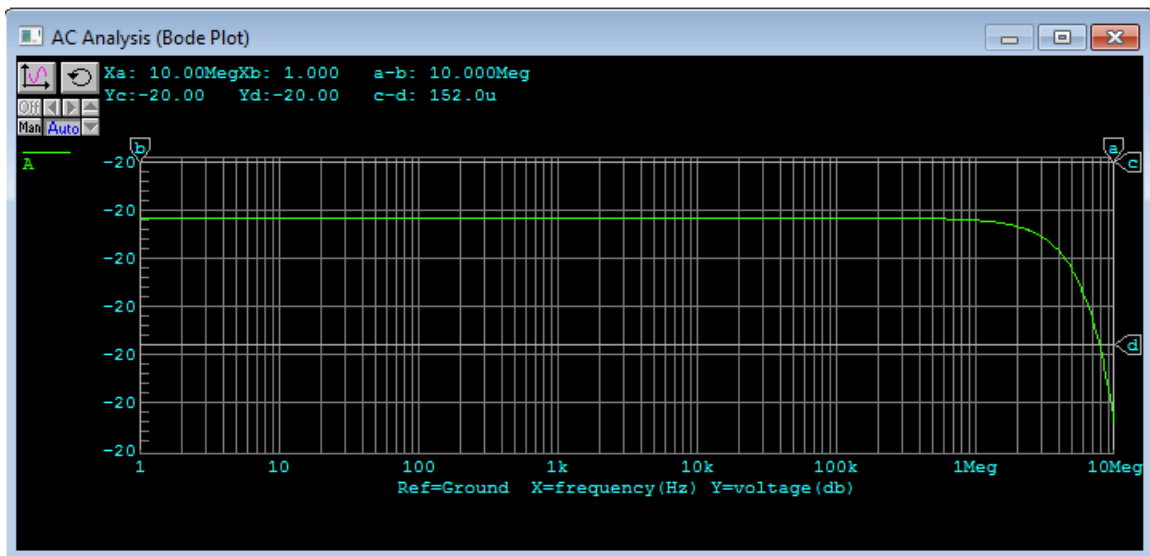
$$V_s = \frac{V_p n_s}{n_p} = \frac{(1V)(10)}{(1)} = 10V$$

$$V_p = \frac{V_s n_p}{n_s} = \frac{(10V)(1)}{(10)} = 1V$$

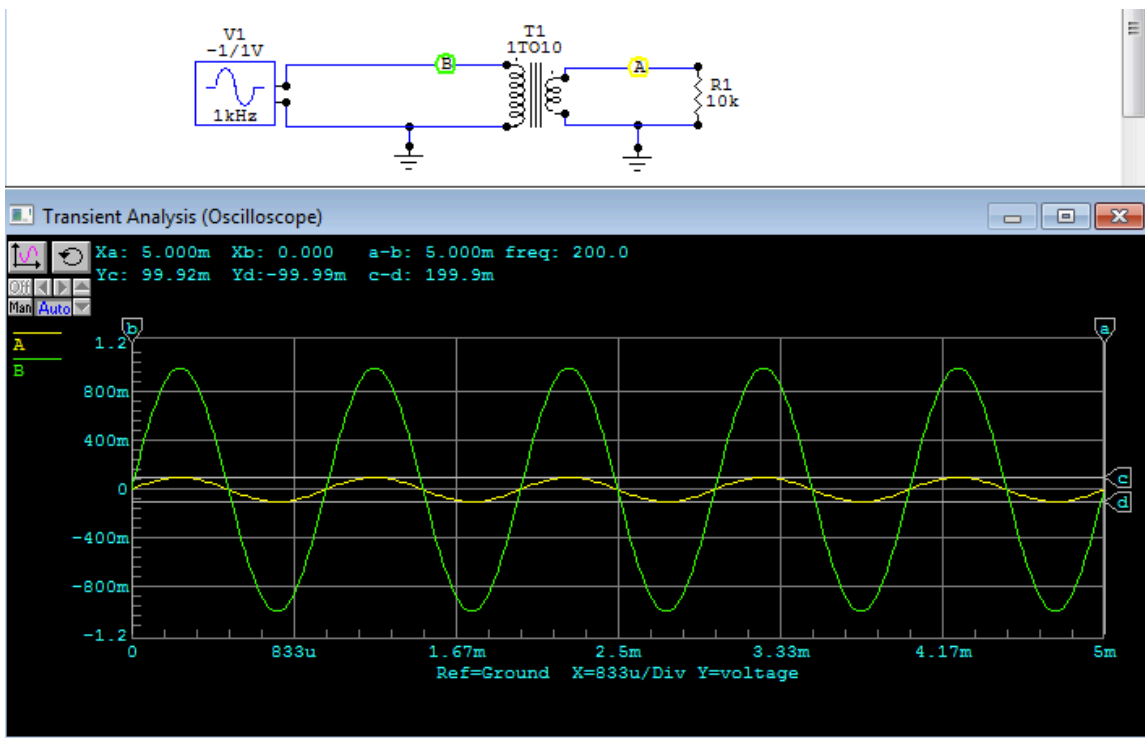
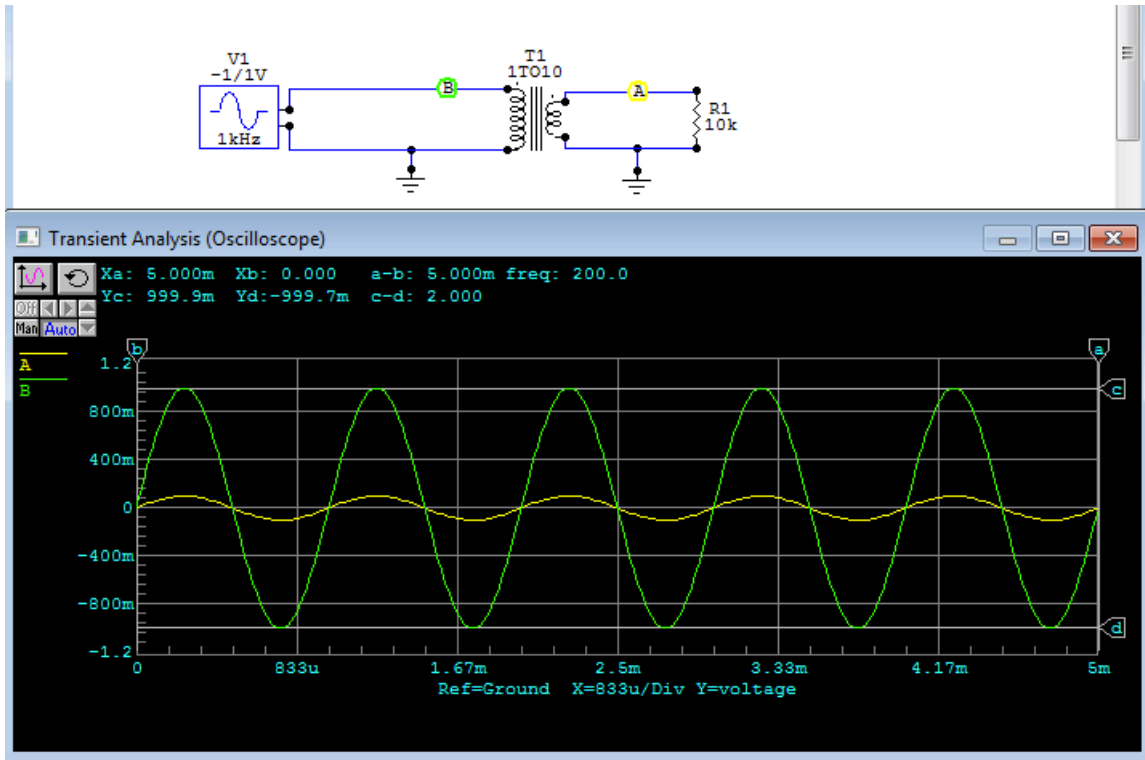
$$dB = 20 \log \left( \frac{V_p}{V_s} \right)$$

$$dB = 20 \log \left( \frac{1V}{10V} \right) = -20dBV$$

A constant -20dB for the entire spectrum



c-d shows the P-P amplitude is 2V in the primary voltage and 200mV in the secondary voltage which is 1/10<sup>th</sup> the primary.



## Circuit 2

$$\frac{n_p}{n_s} = \frac{V_p}{V_s}$$

$$\frac{10}{1} = \frac{V_p}{V_s}$$

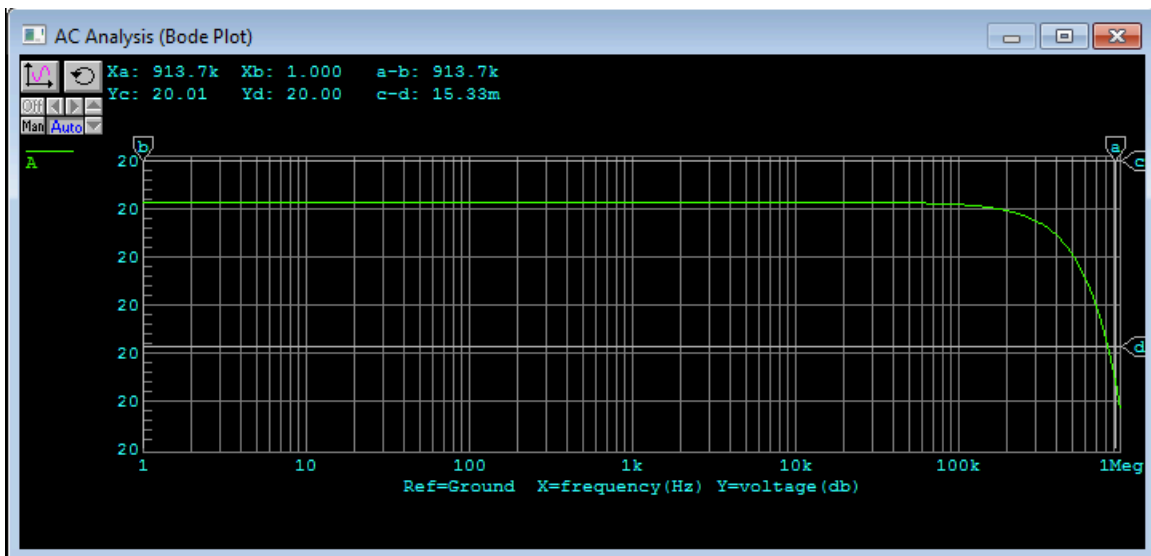
$$V_s = \frac{V_p n_s}{n_p} = \frac{(10V)(1)}{(10)} = 1V$$

$$V_p = \frac{V_s n_p}{n_s} = \frac{(1V)(10)}{(1)} = 10V$$

$$dB = 20 \log \left( \frac{V_p}{V_s} \right)$$

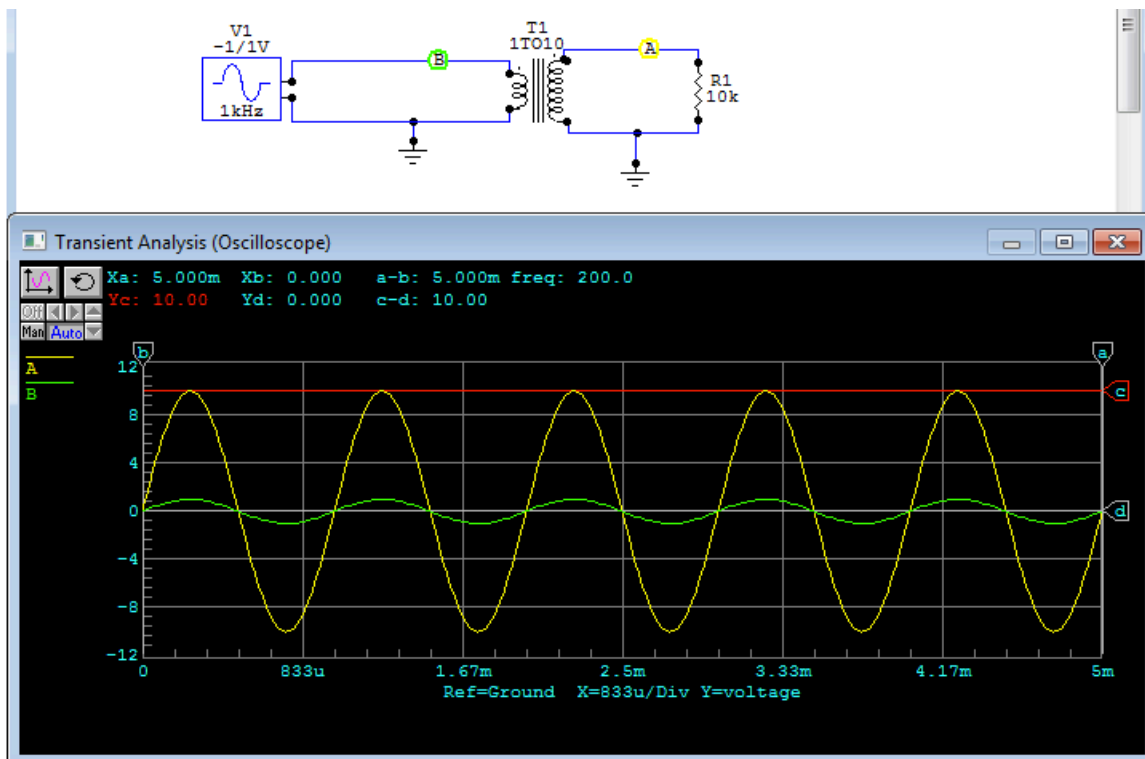
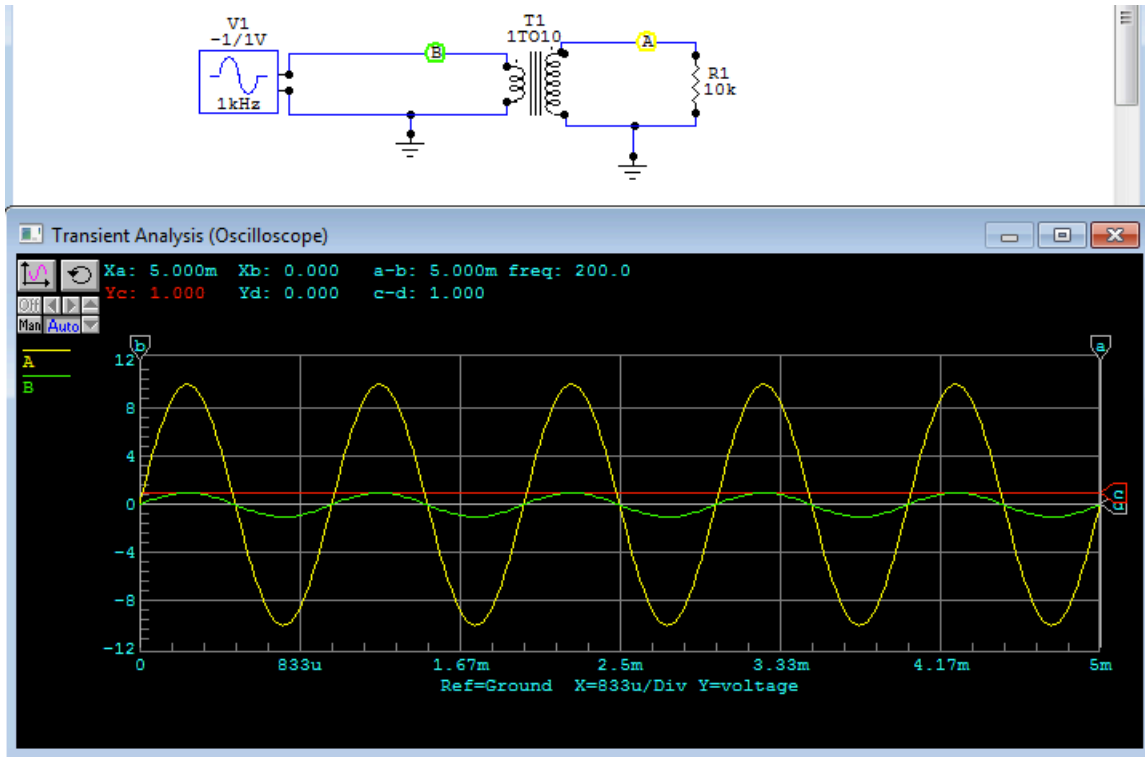
$$dB = 20 \log \left( \frac{10V}{1V} \right) = 20dBV$$

A constant +20dB for the entire spectrum



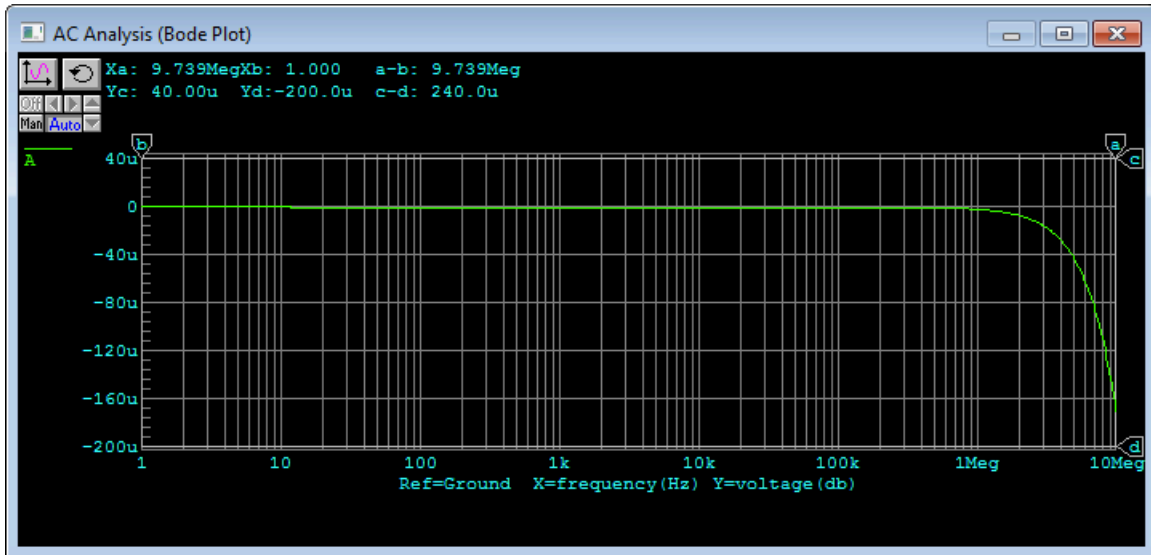


c-d shows the Peak amplitude is 1V in the primary voltage and 10V in the secondary voltage which is 10x the primary.

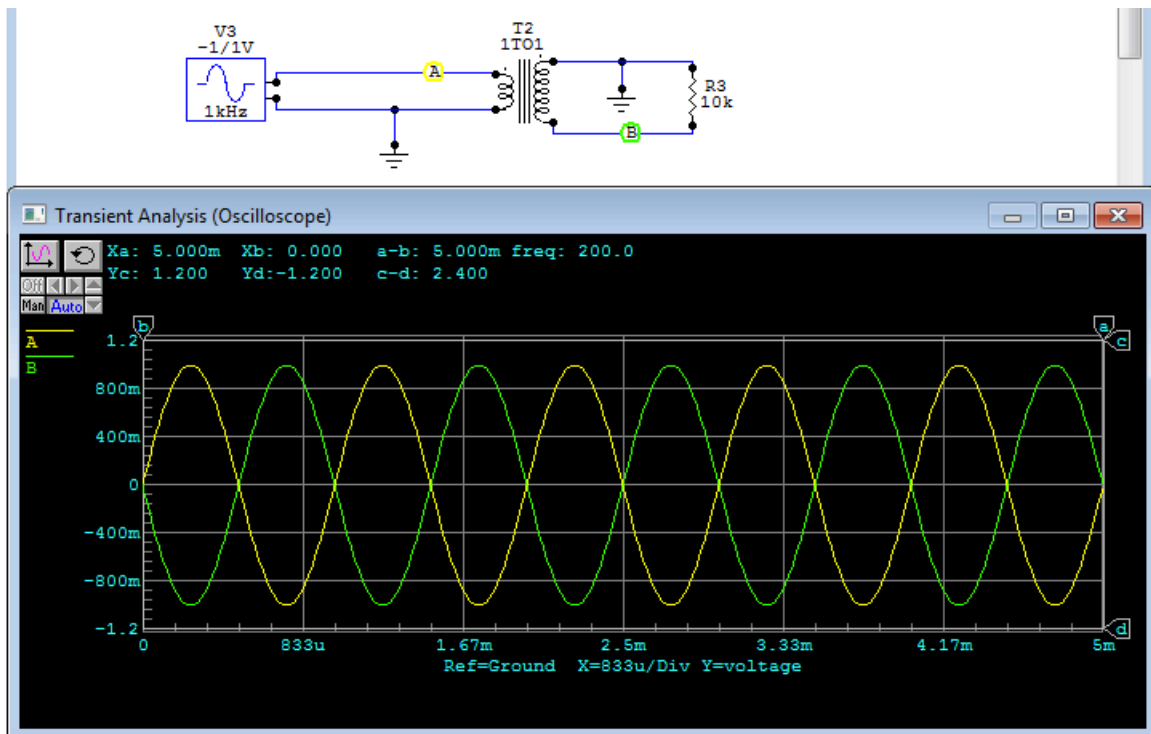


### Circuit 3

Excluding the high supersonic frequencies above 1MegHz, there is unity gain along the entire spectrum.

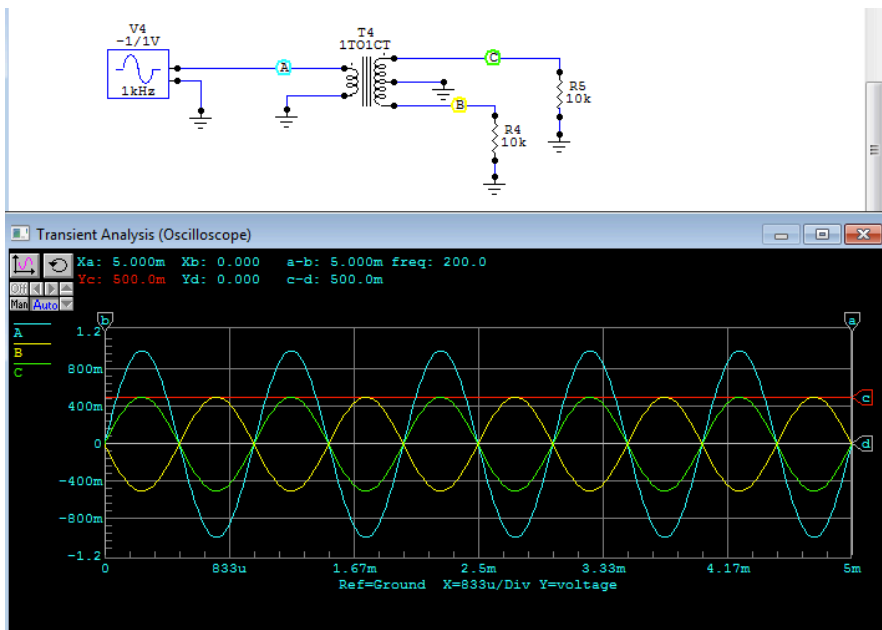
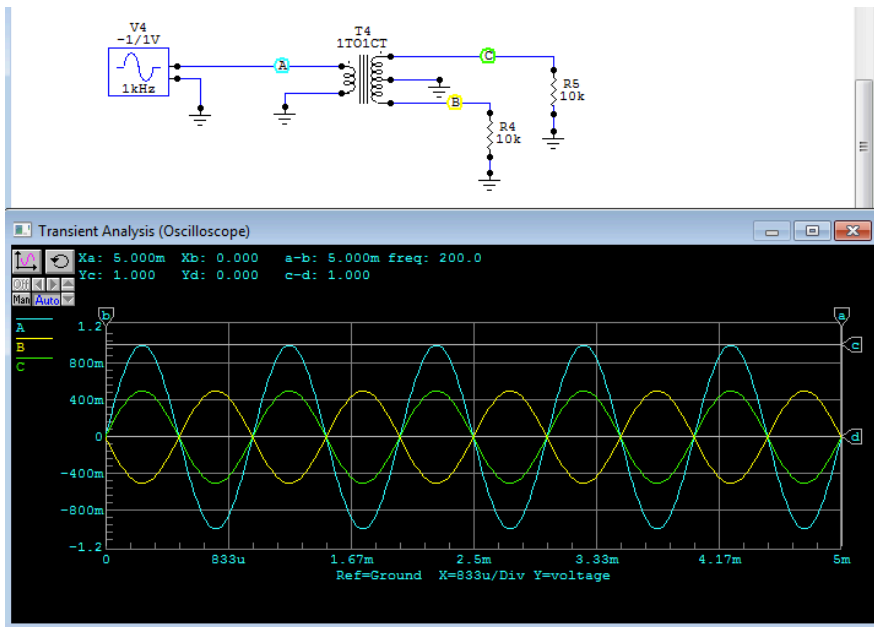


The input and output signal experiences no voltage gain but instead is phase shifted 180 degrees



## Circuit 4

c-d shows the input voltage to be 1V and the output voltages to both be .5V  
The AC voltages at the output are  $\frac{1}{2}$  the input because when you convert a signal from unbalanced-balanced you split the signal in half. Through signal subtraction, each balanced signal is  $\frac{1}{2}$  the original unbalanced signal.



## Circuit 5

c-d shows the input voltages to be 1V each and the output voltage to be 2V  
The AC voltages at the input are  $\frac{1}{2}$  the output because when you convert a signal from balanced-unbalanced you sum the two balanced signals together. Added together they create a 2V signal.

